Collision Avoidance During Flight Inspection

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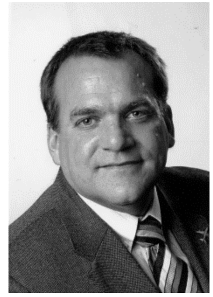

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ABSTRACT

Most accidents and fatalities occur during the departure, initial approach and landing phase of flight. During these phases aircraft fly close to ground in a dense traffic area with increased pilot workload. Flight inspection is performed most of the time in these phases of flight. Many of these profiles are flown in airspace where obstacles and VFR general aviation traffic like gliders, balloons and microlight airplanes can be found. This kind of VFR traffic is typically not transponder equipped and therefore is neither visible to ATC, nor to the flight inspection aircraft's TCAS. Collision avoidance from this traffic or obstacles is just realized on a see and avoid basis. Especially gliders with their slim shape are hard to see and form a big potential hazard to the flight inspection aircraft. Today, most of the general aviation traffic is equipped with a TCAS independent collision avoidance system named FLARM (FLight AlaRM). FLARM has been designed as low cost system for easy installation in gliders and light airplanes. In order to increase safety during flight inspection it is desirable to provide FLARM traffic information to pilots in addition to TCAS. While FLARM equipment, in the size of a cigarette box, can easily be mounted in gliders and microlight airplanes as standard equipment, the installation in a typical flight inspection aircraft requires engineering and STC certification.

This paper explains FLARM in theory of operation and describes the implementation, certification and experiences with FLARM in a twin engine turbo prop flight inspection aircraft.

INTRODUCTION

The protection of the airspace around airports differ between international airports and regional airports.

The airspace at international airports are typically formed by a Controlled Traffic Region (CTR) surrounded by a large controlled airspace classified as airspace "C" or "D" to ensure all traffic is identified in this area .

Regional airports typically do only have a CTR protecting mainly the final approach sector. The surrounding airspace here is classified as airspace "E". Within airspace "E" you can find a mixture of IFR and VFR traffic. A lot of VFR traffic neither has ATC contact nor has transponder (or the transponder active) so they are invisible to ATC. Such traffic could be:

- Piston Aircraft
- Helicopters
- Gliders
- Balloons

Neither traffic information about such VFR traffic can be provided by ATC, nor is TCAS indicating or alerting. Traffic avoidance is based on “see-and-avoid” basis only. A lot of attention must be paid by VFR and IFR pilots on airspace monitoring. To a certain extend VFR pilots are trained to expect IFR traffic in the extension of runway centerlines.

Flight Inspection of radio navigation aids requires to fly numerous non-standard maneuvers. Besides approaches, the maneuvers for ILS calibration include partial orbits through the approach sector at distances of e.g. 7 NM, 17NM and 25 NM or level runs from 25NM. The altitude for these profiles is between 1000ft – 2500ft AGL. In this area fast flying twin engine aircraft are not expected by the normal VFR traffic.

Another hazard in these areas are obstacles like antenna masts and windmills, which form a big threat to the flight inspection aircraft.

A lot of time the flight inspection aircraft is flying outside the protecting CTR in areas where VFR pilots do not expect fast flying IFR traffic. The following picture shows a typical flight pattern performed for an ILS inspection:

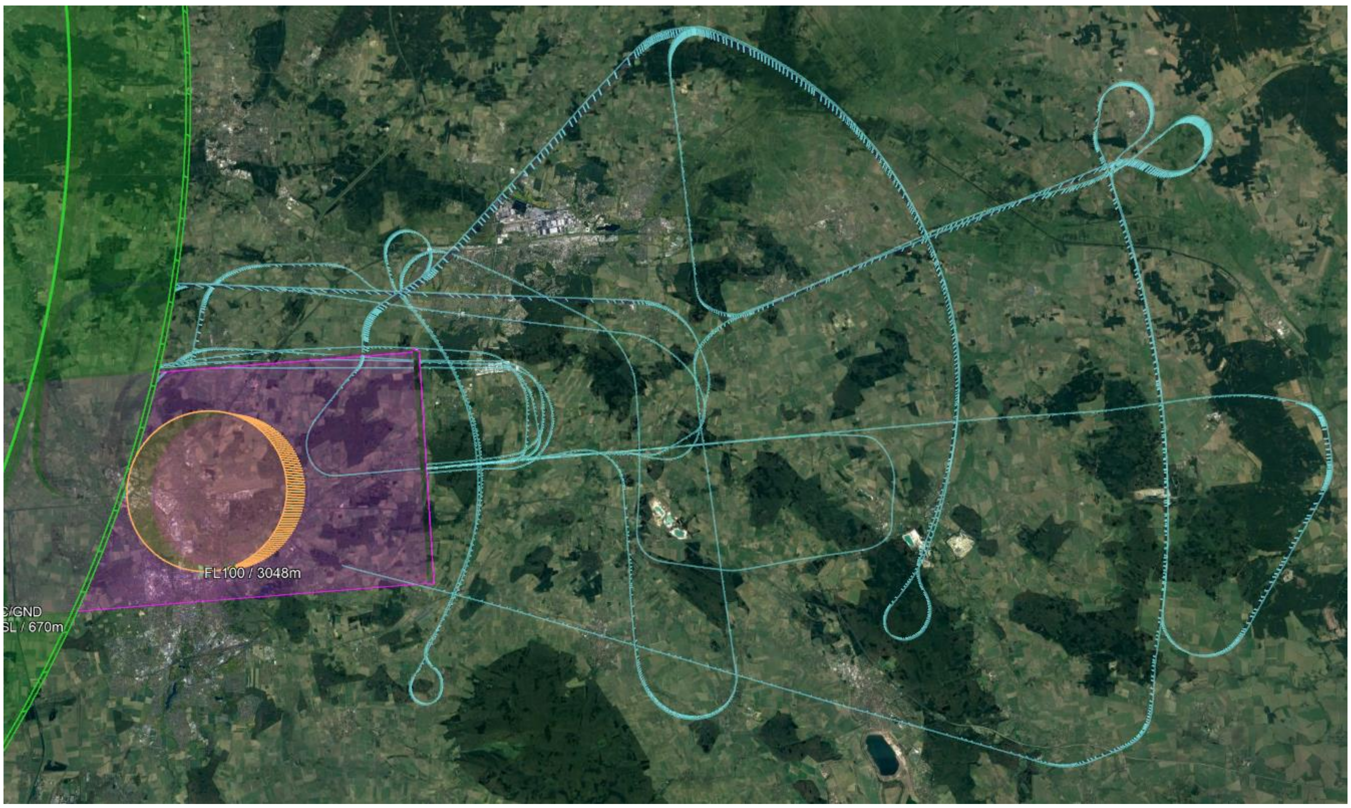

Figure 1 Flight Path ILS Calibration

In the event of an approximation between the flight inspection aircraft and e.g. a glider, it is the flight inspection aircraft that must give way to the glider. In case of a collision threat, only the fast flying flight inspection aircraft can avoid the slow flying glider. Unfortunately gliders with their thin silhouette are very hard to detect. Quite often the white gliders fly close to the cloud base, which makes it even harder to see them:

Figure 2 Glider Silhouettes

In Germany we have about 7100 gliders registered. Very often gliders fly in clusters when gaining altitude in thermals. For the fast flying flight inspection aircraft gliders and other traffic without transponders must be considered a severe hazard.

FLARM

After a significant number of tragic glider midair collisions the low cost collision avoidance system FLARM (FLight alARM) has been invented in the year 2004 by a group of pilots and engineers. The aim was to have a huge number of gliders equipped with the affordable compact and easy to install FLARM system.

Figure 3 Classic FLARM

The introduction of FLARM was a great success for the general aviation. Today about 40.000 units are in use worldwide.

Theory of Operation

A FLARM system integrates a GPS receiver, a processing unit and a telemetry modem, some units also integrate a display and an alarm horn.

FLARM determines its own position based on GPS and transmits this position via the telemetry to other FLARM units. Via the same telemetry the position as transmitted by other FLARM units is received. Bearing, distance and elevation to the other traffic is computed. Based on the own motion vector and the motion vector of other FLARM equipped traffic FLARM identifies potential collisions. The following alert levels are distinguished:

- No Alert (traffic information only)
- Alert 1: Collision in 15 seconds
- Alert 2: Collision in 10 seconds
- Alert 3: Collision in 5 seconds

FLARM further hosts a very detailed obstacle database that includes:

- Wind turbines
- Power Lines
- Cable ways and installations of cable cars
- Masts

The information about other traffic, obstacles and collision alerts are displayed by the integrated FLARM display. In addition FLARM provides data interfaces in RS232 for indication by external displays.

Figure 4 External FLARM Displays

<u>FLARM Installation in Small Aircraft</u>

The installation of FLARM in gliders is considered “Standard Installation” that can be performed by the pilot or owner himself. In many gliders the FLARM unit with the integrated display is simply attached to the glare shield and connected to a power source.

A generic EASA minor change approval exists, that certifies the installation of FLARM in a variety of small aircraft like single engine piston aircraft.

This simple installation in combination with the low price for the FLARM itself leads to the situation that almost every glider, power glider and numerous small airplanes are equipped with FLARM nowadays.

Figure 5 Typical FLARM Installations in Small Aircraft

But how can the flight inspection aircraft gain from this technology that has demonstrated to contribute to better situation awareness and less midair collisions?

FLARM Installation in Flight Inspection Aircraft

The typical flight inspection aircrafts are **not** covered by the above mentioned minor change approval for the FLARM installation. These aircraft are larger aircraft classified as Part 23 (Normal or Commuter Aeroplanes) or Part 25 (Large Aeroplanes) aircraft. The FLARM installation in these types of aircraft requires individual certification by FAA or EASA.

What belongs to the FLARM installation in the flight inspection aircraft?

- Two antennas must be installed on the (pressurized) fuselage skin:
  - GPS antenna
  - FLARM telemetry antenna (L-Band type)
- An additional circuit breaker is required to be installed in reach of the pilots
- A FLARM On/OFF switch must be installed in the cockpit
- An Airplane Flight Manual supplement must be issued and approved by the authority
- The FLARM installation must be described in the Airplane Maintenance Manual supplement, including instructions for continued airworthiness.
- Training requirements may need to be addressed in the Flight Crew Data (FCD) as part of the Operational Suitability Data (OSD)
- If aircraft dispatch shall be possible with an inoperative FLARM system, the FLARM must be included to the Master Minimum Equipment List (MMEL), therefore a supplement to the MMEL is required, which must be approved by the authority.

A variety of requirements must be addressed during the certification process, in order to ensure that by the FLARM installation no additional hazard is created. Typical requirements are:

- Vibration and Buffeting
- Pressurized cabin loads
- Fatigue
- Pilot Compartment View
- Fire protection
- Lightning protection
- Arrangement and visibility
- Warning, Caution and advisory lights
- …

Another challenge in the flight inspection aircraft is: How to indicate traffic or obstacles to the pilot?

- The available FLARM displays are typically very bright, since they are designed for daytime operation only. Normally these displays are LED type and not dimmable, as required for the flight inspection aircraft.
- The pilot view must not be compromised by the installation of the FLARM.
- In case of traffic or obstacle warning, pilots should be forced to look out, instead of looking to a display in the cockpit.

For the given reasons a standard FLARM display as typically used in small aircraft is no suitable option for the flight inspection aircraft.

As a result of a safety assessment it has been identified that aural voice warnings provided to the pilots would be the best solution, as long as they cannot be mixed up with TCAS traffic or resolution advisories.

The next question was how to generate these aural voice alerts?

FLARM Aural Warning Generator

Low cost voice modules for FLARM that can generate audio with FLARM traffic and obstacle warnings are commercially available. These commercially available voice modules were found not suitable for the flight inspection aircraft for the following reasons:

- Quality not compliant with environmental conditions and fire protection requirements
- Use of incompatible units (metric) for aural warnings
- Future availability (short lifetime)
- No EASA Form 1

To overcome these issues a new qualified device (AD-EVP-0200) have been developed that fulfils the requirements for the flight inspection aircraft.

- Converts digital RS232 FLARM data into tone/speech audio warnings
- Designed for airborne applications
- Tested according to RTCA-DO160E
- Aerodata developed source code
- Full configuration and source control

Figure 6 FLARM Aural Warning Generator

The Aural Warning Generator receives FLARM data in RS232 format and generates tone and speech audio output for connection to the aircrafts intercom system. Via an unmuted audio input the audio warnings are provided to the pilots. While TCAS advisories are spoken loud by a sharp male voice, FLARM warnings are provided by a soft female voice with less volume. This allows to distinguish between warnings with high priority (TCAS) and low priority (FLARM).

Different alert levels are classified according to their severity:

1) TRAFFIC INFORMATION
   only information, no collision predicted, example:
   "GLIDER, ELEVEN O CLOCK, TWO POINT SEVEN MILES, HIGHER"

2) ALERT
   collision predicted in 15 seconds, example:
   "**BEEP**, HELICOPTER, TWO O CLOCK, ONE POINT TREE MILES"

3) ALERT
   collision predicted in 10 seconds, example:
   "**BEEP BEEP**, AIRCRAFT, TWELVE O CLOCK, POINT SEVEN MILES"

4) ALERT
   collision predicted in 5 seconds:
   "**SIREN**, PARACHUTE, ONE O CLOCK, POINT ONE MILE, ABOVE"

FLARM installation in King Air

The elements of the FLARM installation in the flight inspection aircraft (King Air B300) aircraft are:

- Power FLARM unit
- GPS Antenna
- Telemetry Antenna
- Aural Warning Generator
- Interface to A/C Audio System
- Control Switches (Cockpit)
- Circuit Breaker (Cockpit)

The control switches in the cockpit allow to power on/off the FLARM, provide FAIL indication and allow to suppress FLARM aural warnings while keeping the FLARM active, so that the flight inspection aircraft remains visible to other FLARM receivers.

Figure 7 FLARM Installation

The FLARM traffic and obstacle information is further provided to the AFIS for recording and display on the Operator's Moving Map in the cabin. In addition to FLARM also the aircraft TCAS is interfaced by the FIS. This allows to display FLARM traffic and obstacles together with TCAS traffic on the AFIS Moving Map.

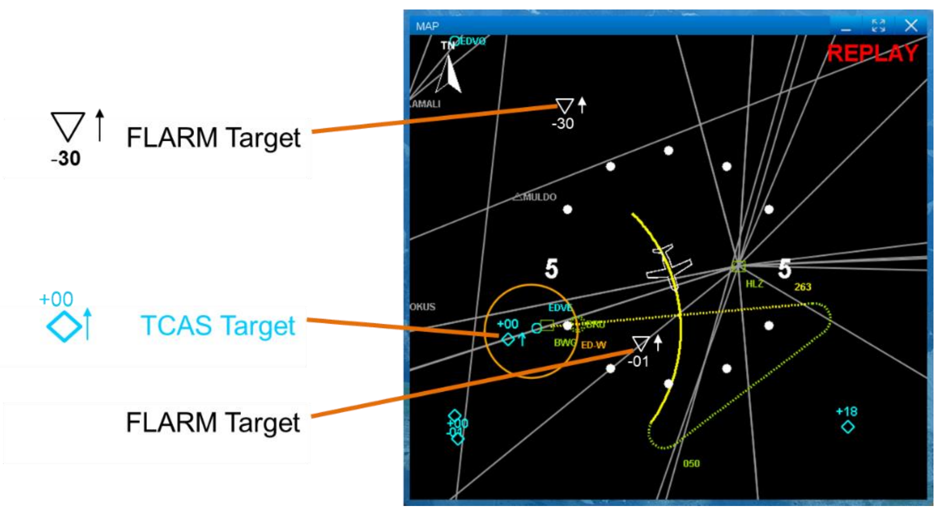

Figure 8 Traffic Display on AFIS

By this full situation awareness is provided to the AFIS operator and is recorded together with the flight inspection data. This feature enables to identify other traffic that might affect the current flight inspection measurements. This feature is also available during replay of flight inspection data. Departing aircraft causing fluctuations on localizer measurements are clearly documented.

CONCLUSIONS

We have received very positive feedback from the pilots using FLARM during flight inspection. The traffic can be received in a range of about 7NM – 3NM, which provides sufficient response time for visual recognition. Traffic information has been

provided which would have not been noted without the help of FLARM. Obstacles are automatically reported by FLARM and can be easier identified by pilots.
FLARM on board of flight inspection aircraft is a helpful system to increase situation awareness and contributes to better Safety.

RECOMMENDATIONS

FLARM is recommended to be installed on flight inspection aircraft, whenever flight inspection is performed in airspace where separation to general aviation traffic cannot be ensured by ATC.